

Secondary pollutants from ozone reaction with nicotine on surfaces

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Summary: *Nicotine, a principal constituent of tobacco smoke, sorbs strongly to indoor surfaces and can be exposed to the action of ozone and other atmospheric oxidants over extended periods. In this study, performed in a 200-L chamber, nicotine sorbed to model surfaces (Teflon, cotton, gypsum wallboard) reacted with ozone at levels that are typical from indoor environments. Formaldehyde, N-methyl formamide, nicotinaldehyde and cotinine were identified as stable oxidation products in air samples, suggesting that aging processes on surfaces can lead to long-term low-level formation of toxic air chemicals.*

Keywords: *nicotine, ozone, surface chemistry*

1 Introduction

Nicotine sorbs rapidly and extensively to indoor materials. This phenomenon reduces nicotine levels in indoor air immediately following smoking. Under repeated smoking nicotine accumulates on materials, as evidenced by increasing rates of mass desorption that yield higher air background concentrations. This study explored the oxidation of nicotine sorbed on model materials with ozone in dry or humid air at typical indoor O₃ levels (14-40 ppb). The role of these oxidation reactions as a long-term low-level source of secondary pollutant was evaluated [1].

2 Methods and Results

The reaction of ozone with nicotine sorbed to model surfaces was investigated in a 200-L Teflon environmental chamber by monitoring nicotine sorption and subsequent desorption over periods of 2 and 7 days respectively, following equilibration in dry or humid air (65-70 % RH). Identical desorption conditions were evaluated in the presence and absence of ozone. Gas phase samples collected during the desorption period were analyzed for the identification and quantification of volatile oxidation products. The investigated surfaces were Teflon (the empty chamber), cotton and gypsum wallboard. Compared with dry air baseline levels in the absence of ozone, gas phase nicotine concentrations decrease, by 2 orders of magnitude for Teflon after 50 h at 20-45 ppb O₃, by a factor of 10 for cotton after 100 h with 13-15 ppb O₃ and by two orders of magnitude after 100 h for wallboard. The ratios of pseudo first-order rate constants for surface reaction (r) to long-term desorption (k) were $r/k = 3.5$, 2.0 and 2.5 for Teflon, cotton and wallboard surfaces, respectively.

Formaldehyde, N-methyl formamide, cotinine and nicotinaldehyde were identified as oxidation products. The presence of water vapor had no effect on the nicotine-O₃ reaction on Teflon and wallboard surfaces. By contrast, nicotine desorption from cotton in humid air was unaffected by the presence of ozone.

3 Discussion

These results show that surface oxidation is a significant chemical sink for sorbed nicotine, comparable with re-emission into the gas phase. Based on these results, oxidative losses could significantly reduce long-term re-emissions of nicotine from indoor surfaces into the gas phase, while generating comparable or higher levels of secondary airborne oxidation products. The molecular structures of identified oxidation products indicate that the pyrrolidinic N in nicotine was the site of electrophilic attack by O₃. The effect of humidity on cotton surfaces is consistent with complete inhibition of ozone-nicotine surface reactions in an aqueous surface film present in cotton but not in Teflon or wallboard surfaces. Hence, the nature of material surfaces in combination with ambient relative humidity determine the extent of ozone-nicotine reactions.

Reference

[1] H. Destailats, B.C. Singer, S.K. Lee and L.A. Gundel. The effect of ozone on nicotine desorption from model surfaces: evidence for heterogeneous chemistry. *Submitted*.